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USSR: Production of Electronic Instruments

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USSR: Production of Electronic Instruments

Central Intelligence Agency
Directorate of Intelligence

August 1977

Key Judgments

- Soviet output of electronic instruments has grown at an average annual rate of 15 percent over the past decade, reaching an estimated level of $1.6 billion in 1976.

- The technological level of output remains 10 years or so behind the level in the United States, Western Europe, and Japan, primarily due to a shortage of modern semiconductors.

- Imports of electronic instruments, which were valued at an estimated $50 million in 1975, feature advanced types in short supply or types not produced at all in the USSR; roughly 70 percent of imports came from East Germany, Hungary, and Czechoslovakia in the late 1960s, and this proportion probably holds true today.

- Soviet technical and engineering personnel are often handicapped by an inability to obtain modern, high quality instruments, which affects productivity and in some cases limits the quality of their work.

- Because of continuing rapid advances in Western technology, the USSR will have to struggle to keep the gap in electronics instruments from widening over the next several years.

USSR: Production of Electronic Instruments

Introduction

This report analyzes Soviet production of electronic instruments, discussing the types and level of output, the quality of output, its adequacy for domestic needs, foreign trade in electronic instruments, and the organization and management of the domestic industry. The discussion is limited to instruments in series production used by the general scientific-engineering community and does not analyze Soviet technical capabilities in highly specialized types built in small quantities or assess the scientific state-of-the-art.

The term "electronic instruments" is used throughout this report as essentially equivalent to Standard Industrial Classification Category 3825–Instruments for Measuring and Testing of Electricity and Electrical Signals. Examples include general-purpose test-and-measuring instruments such as oscilloscopes and signal generators, component testers, chart recorders, and indicating meters. The term does not include such items as aircraft instruments, medical instruments, industrial process instruments, or instruments for measuring chemical or physical properties.

Production and Domestic Supply

Production of electronic instruments in the USSR grew steadily at an average annual rate of 15.5 percent from 1965 to 1975 (table 1).[1] Output in 1975 was valued at 1.1 billion rubles, or about $1.4 billion. This compares with a 1975 output in the US of $2.1 billion (figure 1).[2]

The value of production of electronic instruments in 1976 and planned output for the Tenth Five-Year Plan have not been announced. The output of instruments of all types is

[1] In the USSR, electronic instruments are classified, somewhat arbitrarily, into two categories, electrical measuring and radio measuring. Electrical measuring instruments include panel meters, chart recorders, low frequency voltmeters, galvanometers, and bridges. Radio measuring instruments include oscilloscopes, spectrum analyzers, high frequency voltmeters, and frequency standards. Electrical measuring instruments may generally be thought of as operating at DC or low frequencies and oriented to industrial applications. Radio measuring instruments tend to operate at higher frequencies and are oriented to testing electronic equipment such as computers, communications equipment, or radar.

[2] Figures for the dollar value of Soviet output given in the text and figure 1 were derived using a rate of one ruble equals $1.3. This ratio is based on a fragmentary comparison of Soviet and US instrument prices; it should be considered subject to a wide margin of error.

Table 1

USSR: Output of Electronic Instruments

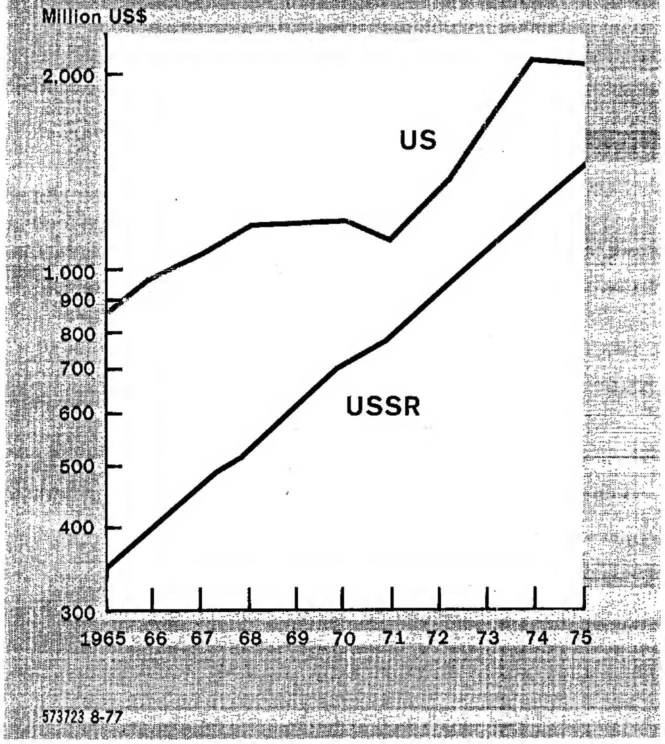
Million Rubles [1]

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976 [2]
Total	260	306	356	401	463	539	601	695	802	943	1,098	1,260
Electrical Measuring	159	193	224	253	287	314	351	402	461	533	623	715
Radio Measuring	101	113	132	148	176	225	250	293	341	410	475	545

[1] Factory wholesale prices of 1 July 1967.
[2] Estimated.

Figure 1

US and USSR Production of Electronic Instruments



planned to grow at about the same rate during the period 1976-80 as was actually achieved in 1970-75. Therefore it is likely that the output of electronic instruments will continue to grow at about 15 percent per year. Even though growth in Soviet industrial output as a whole has been gradually slackening, output of electronic instruments enjoys priority as part of high-technology industry and is proceeding from a comparatively small base.

Despite the rapid growth and high value of output of electronic instruments, shortages are widespread. In 1974 a senior industry official privately stated that Soviet capability to manufacture all the various types of electronic instruments will remain behind consumer needs for the indefinite future.

Soviet emigres and many qualified visitors to the USSR have reported that available laboratory instruments are greatly inferior not only to those commonly found in US laboratories, but also to the better types in Soviet catalogs. Soviet scientists who have had an opportunity to work in US installations often express amazement at the high quality of instruments routinely available to their American counterparts.

Such comments and observations indicate that Soviet production of electronic instruments is weighted toward older types. The allocation system limits access to better quality instruments to the military and other high-priority users. Thus, the listing of an instrument in a catalog does not necessarily imply its ready availability to the entire scientific-engineering community.

In many instances, the general lag in Soviet technology means that an engineer can get by with a less advanced electronic instrument than would be standard in a leading Western economy. For example, extremely fast integrated circuits are not mass produced in the USSR; thus, less demand exists for wide bandwith oscilloscopes that are needed for design and maintenance of end equipment using such circuits.

In other instances, shortages of advanced electronic instruments do matter. One problem area is in production test equipment for semiconductors, including integrated circuits.[3] The Soviets are making a major effort to build an advanced semiconductor industry and have imported considerable amounts of equipment to supply their semiconductor production facilities.

The shortage of high quality instruments also causes problems for Soviet researchers. For instance, a physicist in an institute developing semiconductors claimed that his coworkers considered their work on III-V materials to be in-

[3] An essential part of the manufacturing process for semiconductors is the testing of individual devices to eliminate rejects (for some extremely complex devices the number of defective units can exceed the number of acceptable ones) and to classify the remaining units according to their technical parameters.

ferior to similar US work because high quality oscilloscopes were not available from domestic sources and could not be imported.[4] Similarly, physicists at another institute complained that their work in semiconductor research was hurt by inability to obtain sensitive electrometers for measuring small currents, despite the fact that such electrometers were in production in the USSR at the time.

Visitors to Soviet research facilities have noted that a high percentage of technical personnel were doing routine measurements and data reduction. The advantage of many modern instruments is that the routine work of multiple measurement, calculation, and presentation of the result is performed within the instrument, freeing technical personnel for other work.

Foreign Trade

The USSR imports about twice as many electronic instruments as it exports. Both imports and exports have increased over the last 10 years, although at a slower rate than domestic production (table 2).[5]

Soviet exports have been weighted toward simpler instruments such as multimeters and inexpensive, obsolescent oscilloscopes for educational institutions. Imports, on the other hand, have emphasized advanced types that are in short supply or not produced in the USSR. Several US instrument manufacturers active in exporting to the USSR have stated that Soviet demand for simpler types is too small to warrant a major marketing effort. However, they have reported high Soviet interest in importing types near or above the COCOM export control levels.

Little useful statistical information is available on Soviet trade in electronic instruments with specific countries.[6] In 1967, the three major East European producers of instruments, East Germany, Hungary, and Czechoslovakia, supplied about 70 percent of Soviet imports. Most of the remainder came from Japan and Western Europe, a considerable portion from US subsidiaries or distributors, but less than 2 percent came directly from the US.[7] Over 90 percent of Soviet exports were to Eastern Europe, Asian Communist countries, and Cuba. Although precise figures for recent years are not available, the distribution of trade probably has not greatly changed.

The elimination of US unilateral export controls and the relaxation of COCOM controls, both in terms of removal of items from control and in willingness to approve exports of items still on the control list, appear to have had little effect in alleviating the overall Soviet shortage of higher quality electronic instruments. Prestige and influence, as well as technical need, are major factors in determining allocations of hard currency for importing instruments, and the

[4] The III-V compounds are a group of semiconductor materials with applications in laser diodes, radiation detectors, solar cells, and microwave devices.

[5] Data in table 1 on production and table 2 on trade are not directly comparable because different methodologies were used to compile the value figures.

[6] The USSR ceased publishing such information in 1968. Foreign trade statistics published by other countries are generally too aggregative either as to commodities or countries to be useful.

[7] Such direct US exports to the USSR were valued at about $600,000 in 1974 and $700,000 in 1975 (FAS point of export). The value of sales of US instruments made indirectly through foreign subsidiaries or distributors cannot be recovered from the statistics of third countries.

Table 2

USSR: Estimated Exports and Imports of Electronic Components

Million Rubles [1]

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Exports	8.3	7.7	8.4	9.0	10.1	12.0	13.8	15.7	15.5	17.3	18.8
Imports	15.9	12.3	12.2	14.9	18.6	21.0	25.1	29.2	27.3	30.1	38.2

[1] Current prices, f.o.b. port of export.

procedures for obtaining such allocations are bureaucratic and time consuming.

Organization and Administration

The Soviet electronic instrument industry has 21 major production facilities, located mainly in the western USSR. Electronic instruments are mostly produced by the Ministry of the Radio Industry (MRP) and the Ministry of Instrument Building, Means of Automation, and Control Systems (Minpribor). A small amount of output comes from enterprises, institutes, and design bureaus of other ministries and departments.

The Sixth Main Administration of the MRP has primary responsibility for production of radio measuring instruments. The MRP is officially classified as part of the defense industry. Although instruments produced by the MRP are described in catalogs and other open source material, information on production facilities (including in some cases even the mere fact of their existence) is considered highly sensitive. Many MRP instrument plants are never mentioned in the open literature. Others have been mentioned by name, but with no information about the nature of production.

Production of electrical measuring instruments is the responsibility of Minpribor's Soyuzelektropribor Industrial Association. In contrast to the MRP, information on Minpribor's instrument plants is less closely held, even though many of them produce items for the military.

Table 3 lists the major Soviet producers of electronic instruments. It is believed to include all facilities of Minpribor that are major producers of electrical measuring instruments, but, in the case of the MRP, evidence exists of another four or five instrument producers. These other producers are probably either recently established plants not yet identified or Scientific Research Institute (NII's) where the existence of production facilities has not been confirmed.

Technology

The technology of more complex Soviet electronic instruments lags behind Western levels by about 10 years. For example, portable oscilloscopes are limited to 50 MHz bandwidth, compared to 350 MHz in the West. Conventional laboratory types are only available in the USSR with bandwidths up to 100 MHz; 500 MHz versions are made in the US.

Soviet instruments using digital techniques show a similar technological lag. The best Soviet digital counter operates at a 100 MHz direct count rate, or at 200 MHz with prescaling. Comparable figures for the US are 500 MHz and 1000 MHz. Even those Soviet instruments that have the same major technical characteristics as Western instruments are generally inferior in other important parameters. For example, Soviet oscilloscopes typically have poorer sensitivity (amount of deflection on the screen per unit signal applied) than Western models with the same bandwidth. Soviet spectrum analyzers have poorer resolution and sensitivity (strength of minimum detectable signal) than Western models operating in the same frequency range.[8]

The reason for the Soviet lag is primarily a lack of modern electronic components, especially semiconductors. The Soviets are far behind the West in mastering the production of economical, high-performance planar transistors. Mass production of monolithic digital integrated circuits in the USSR did not begin until the early 1970s.

Until recent years Soviet instruments were based primarily on electron tube designs, although there was some use of germanium transistors. In the early 1970s, the use of transistors and integrated circuits began to increase in newer designs. However, many older models with designs dating back at least 10 years continue to be produced, implying that many Soviet engineers and technical personnel do not have access to more modern Soviet instruments.

[8] See appendix A for a detailed discussion of several classes of Soviet electronic instruments.

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Table 3

USSR: Major Producers of Electronic Instruments

Location	Name	Subordination	Comments
Bryansk	Instrument plant[1]	MRP	Major oscilloscope producer.
Cheboksary	CEAZ Electrical Measuring Apparatus	Minpribor	Panel meters, digital voltmeters, miscellaneous electrical measuring instruments.
Gorkiy	Frunze Plant	MRP	Major signal generator producer.
Kiev	Tochelektropribor	Minpribor	Major producer of electrical measuring instruments.
	Radiopribor	MRP	Miscellaneous radio measuring instruments.
Kishinev	Mikroprovod	Minpribor	Microwire resistance standards and bridges.
	Vibropribor	Minpribor	Direct-writing oscillographs, tape recorders.
Krasnodar	Measuring Instruments Plant	Minpribor	Miscellaneous electrical measuring instruments.
Kursk	Instrument plant[1]	MRP	Suspected producer of network analyzers, sweep generators.
Leningrad	Vibrator	Minpribor	Large producer of miscellaneous electrical measuring instruments.
L'vov	V. I. Lenin Production-Technical Association	MRP	Former Izmeritel Plant No. 125. Major producer of radio measuring instruments including oscilloscopes, voltmeters, digital counters, and frequency meters.
	L'vovpribor	Minpribor	Former Teplokontrol Plant. Miscellaneous electrical measuring instruments, including bridges, potentiometers, also micromodule and hybrid integrated circuits.
Minsk	V. I. Lenin Radio Measuring Instrument Plant	MRP	Reportedly now part of the Etalon Association. Miscellaneous radio measuring instruments.
Omsk	Elektrotochpribor	Minpribor	Major producer of panel-mounted and laboratory electrical measuring instruments.
Tallinn	Punane Ret	MRP	Miscellaneous radio measuring instruments.
Uman	Megommetr	Minpribor	Panel meters.
Vilnyus	Radio Measuring Instruments Plant	MRP	Former Plant No. 555. Major producer of oscilloscopes, signal generators, microwave instruments.
	Scientific Research Institute for Radio Measuring Instruments (NIIRIP)	MRP	In addition to designing instruments, NIIRIP reportedly manufactures oscilloscopes, signal generators, and other instruments.
Vitebsk	Electrical Measuring Instrument Plant	Minpribor	Miscellaneous electrical measuring instruments.
Yerevan	Elektrotochpribor	Minpribor	Microammeters, millivoltmeters.
Zhitomir	Elektroizmeritel'	Minpribor	Miscellaneous measuring instruments.

[1] Name of plant is not available.

Continued production of obsolete instruments could be the result of any or all of the following: the common Soviet bureaucratic reluctance on the part of plant management to give up the production of established profitable models; a recognition that in many cases obsolete instruments are adequate; and a shortage of the components needed to build newer models. The latter seems the most likely explanation, however. The Soviets are still in the early stages of building up capability to produce modern silicon semiconductors, and consumers other than the instrument industry may have higher priority for obtaining semiconductor devices. The belief that components are in short supply is further borne out by the fact that some Soviet technical personnel have said that although they had access to modern Soviet instruments with integrated circuits, it was extremely difficult to get replacement parts.

Several recent articles in Minpribor's monthly technical journal have sharply criticized the Ministry of the Electronics Industry (MEP),

which traditionally has had the responsibility for production of electronic components in the USSR. The articles, written by personnel of the Soyuzelektropribor Association, state that the MEP is unable to supply Minpribor's instrument producers with linear integrated circuits of acceptable quality and that medium- and large-scale integration circuits are not available at all.

Although the more secretive MRP has not made similar public criticisms, it is known that a high percentage of the integrated circuits supplied to its computer producers by the MEP is unacceptable. Given the high priority of the computer industry, it is likely that the MRP's instrument producers suffer from the same problems as Minpribor's.

New Soviet instrument designs, as evidenced by preliminary data sheets and exhibitions of prototypes at trade fairs, indicate a growing technological capability in electronic instruments. Notable examples include a 250 MHz portable oscilloscope, a microwave spectrum analyzer with 8 GHz displayed bandwidth, and a low-frequency, time-compression, real time spectrum analyzer.[9] Whether this design capability will be translated into practical capability will depend on whether the Soviets can master production of the necessary transistors and integrated circuits and deliver them in sufficient quantity to instrument manufacturers.

Even if the Soviets are successful in mass producing recent instrument designs, they will still lag behind the West in technology. The current trend in Western instrument technology is to use complex integrated circuits in new types of "intelligent" instruments which contain the equivalent of a small computer. The slow rate of technical progress in the Soviet integrated circuit industry will not allow the USSR to move very rapidly in this direction. For at least the rest of the decade, the main task of Soviet instrument designers will be to equal the West's technological level of the 1960s.

[9] See appendix A for more detail.

Dependence on the West

The Soviet instrument industry is actively engaged in reverse engineering of Western instruments. Although most imports are for actual use, several Soviet research-and-development facilities have sections that examine and adapt the designs of US, West European, and Japanese instruments, many of them acquired in contravention of COCOM controls.

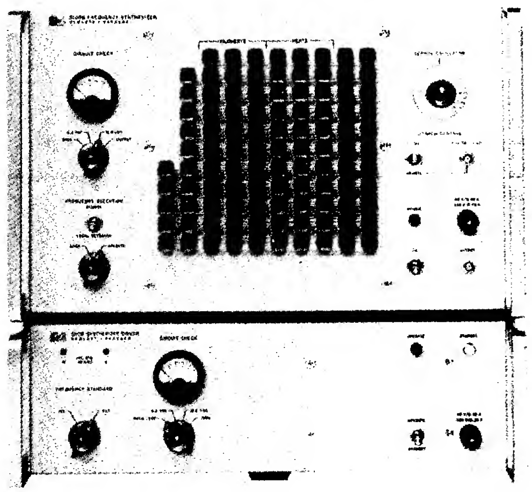
Although the USSR has traditionally exploited foreign technology in this way, in the 1960s it was largely unable to take advantage of Western advances in instrument design. The introduction into widespread use of silicon planar transistors in the early 1960s and monolithic digital integrated circuits in the middle of the decade revolutionized electronic instrument design in the West. Since these components were not available in quantity to Soviet instrument producers, it was impractical to copy Western designs. By the late 1960s, Soviet component technology had improved to the point that Western designs could be usefully adapted.

There are no indications that Soviet activity in copying or adapting Western designs reflects any lack of ability on the part of their design engineers. The unavailability of more advanced electronic components largely restricts the activity of Soviet designers to attempting to equal Western achievements. Articles in the Soviet open technical literature have reminded instrument designers that their foreign counterparts have often solved many of the design problems facing Soviet industry and that it is more efficient to take selective advantage of foreign successes than to work in isolation.

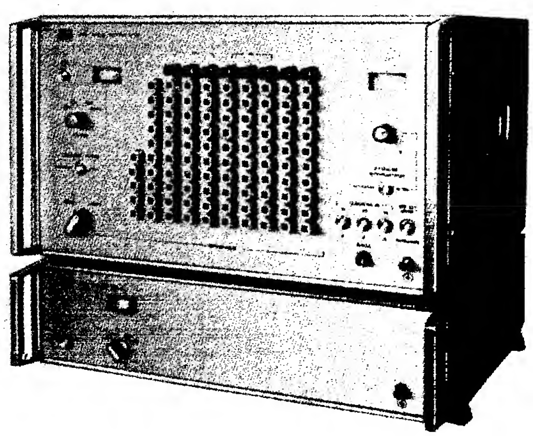
Soviet instrument designers have taken this advice to heart, even when the level of technology is within their own capability. The resulting Soviet product sometimes bears a startling resemblance to its Western ancestor (see figures 2 and 3). However, no cases have been noted where the Soviet copy equals the Western product technically.

Figure 2

Comparison of Soviet and US Synthesizers



Hewlett-Packard Model 5100B/5110B



Soviet Model Ch6-58

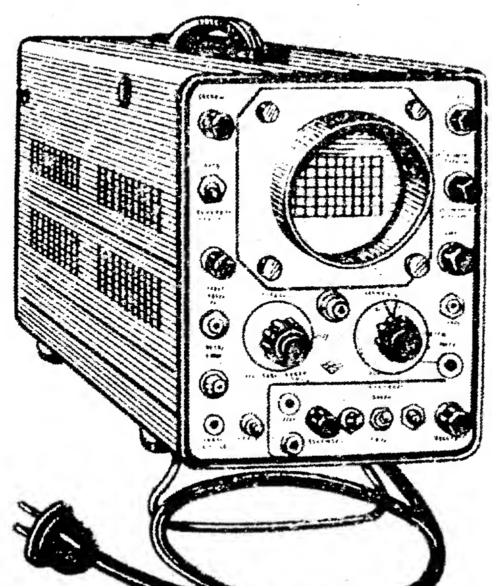
573724 8-77

The recent wave of activity by the Soviets in signing agreements on scientific and technical cooperation with Western companies has not generated any activity in the field of electronic instruments. The Soviets have signed such agreements with at least two major Western manufacturers of instruments. However, they amount to undertakings to explore the possibility of

Comparison of Soviet and US Oscilloscopes

Figure 3

Tektronix Model 321A



Soviet Model S1-49

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joint research and have not yet led to specific projects for electronic instruments. This may be because the Soviets would have little to contribute in the field of electronic instrument technology.

The Soviets also have not been active in seeking manufacturing licenses for electronic instruments. Only two recent inquiries about such licenses are known; one for semiconductor production test equipment and one for data acquisition systems and system components. No licenses are known to have been actually purchased. In any case, it would be difficult for the Soviets to make any major improvement in their electronic instrument technology by seeking foreign licenses without either an accompanying improvement in electronic component technology or a willingness and ability to import components from the West.

APPENDIX A

Technical Characteristics of Soviet Instruments

This appendix is intended to provide a greater insight into Soviet instrument technology than was possible in the body of the paper and to elaborate on some of the analysis therein.

The sources of information for this appendix are Soviet catalogs of electronic instruments offered for sale on the domestic market and preliminary data sheets describing instruments in the development state that have not yet been scheduled for production.

Although there is no reason to believe that instruments described in catalogs are not in fact in production, the reader should not assume that such instruments are freely available for sale to any consumer with the necessary funds. There is a seller's market for instruments in the USSR, especially for the newer, more advanced types, which are available only in limited quantities to users with high priorities.

Oscilloscopes

Soviet technology in wide bandwidth oscilloscopes lags behind that of the West by seven to 10 years. Western portable and laboratory scopes are available with five to seven times the bandwidths of the best Soviet models (table 4).

Table 4

Oscilloscope Bandwidth Capabilities

	USSR	Free World
Portable	50 MHz	350 MHz
Laboratory	100 MHz	500 MHz
Sampling	6 GHz	18 GHz
Direct access	1.2 GHz	4.5 GHz

It is often possible to compensate for a lack of conventional wide bandwidth oscilloscopes by using less versatile sampling or lower sensitivity direct access types.[10] The USSR has sampling scopes with rated bandwidths

[10] In direct access oscilloscopes, the signal is applied directly to the cathode ray tube without amplification.

of 6 GHz (6000 MHz), including one programmable model with an associated analog-digital converter and digital readout appropriate for production testing of high-speed semiconductors. A direct access scope with a rated bandwidth of 1.2 GHz and sensitivity of 2 volts per centimeter is available for specialized applications such as laser research, high-energy physics, and nuclear weapons testing. These levels have long been exceeded in the West.

The USSR has made great progress during the past decade in oscilloscope technology. In 1965, Soviet scopes were of generally poor quality by Western standards for bandwidth, sensitivity, sweep versatility, accuracy, linearity, size, and weight. Advances in cathode ray tube (CRT) design and the growing availability of semiconductors, combined with a deliberate effort to copy Western designs, permitted a slow but steady increase in scope capabilities. Although Soviet scopes cannot approach Western capabilities in bandwidth and do not have such convenience features such as digital CRT readout, newer Soviet models are of modern appearance with electrical characteristics generally comparable to their Western counterparts of the 1960s.

The USSR developed several new oscilloscopes and planned to introduce them into production by the end of 1976.[11] The most significant are a sampling scope rated for 10 GHz and a portable dual trace scope using integrated circuits with 250 MHz bandwidth and 10 mv/cm sensitivity. Successful mass production of these units would indicate a considerable improvement in Soviet component and instrument technology and would be of great assistance in the development of high speed computers, fast integrated circuits, and sophisticated digital cryptographic and communications equipment. Nevertheless, their successful production would only maintain and not close the traditional gap between the USSR and the West of seven or more years.

Although Soviet oscilloscope technology is deficient at wider bandwidths, it is adequate for all but the most demanding applications. However, production of the more modern types does not meet demand. The most important facilities have priority access to instruments, leaving lower priority needs unsatisfied. For example, visitors to a Soviet laser research facility have observed several of the more advanced Soviet oscilloscopes in use. On the other hand, a group of Soviet geophysicists, when shown a 10-year-old US 50 MHz scope, stated that they had no access to "such fine gear."

Spectrum Analyzers

Scanning Analyzers

The USSR currently produces several microwave spectrum analyzers with maximum operating frequencies from 2 to 40 GHz. However, their

[11] There is no available evidence to indicate whether or not this plan was successfully carried out.

Table 5

Microwave Spectrum Analyzer Capabilities

	USSR	US
Dynamic Range	53 dB	70-100 dB
Displayed Bandwidth	1.3 GHz	8-10 GHz
Sensitivity	−110 dBm	−125 dBm
IF Filter Bandwidth	1 KHz	30-100 Hz
Residual FM (stabilized)	300 Hz	10-100 Hz

technical characteristics lag well behind US standards (table 5). The dynamic range of Soviet models is quite limited compared to modern US types. Most Soviet models have maximum display bandwidths of only 80 MHz, probably due to Soviet deficiencies in tunable transistorized local oscillators and preselector filters. One recently developed Soviet model is capable of displaying a 1.3 GHz spectrum, implying an improvement in local oscillator capability. However, there are no indications of any use of YIG-tuned preselector filters which would permit tuning with harmonics of the local oscillator to achieve several GHz of displayed bandwidth. Soviet microwave spectrum analyzers are also less sensitive than US models and have poorer resolution due to less stable oscillators and wider IF filter bandwidths. There is no evidence of any new microwave analyzers scheduled for production in the near future.

The USSR also makes lower frequency spectrum analyzers with maximum frequencies from 20 KHz to 270 MHz. At frequencies to 100 MHz and below, their display bandwidths approach or equal the maximum operating frequency, as do Western types. However, as with microwave analyzers, their technical characteristics are inferior in sensitivity, resolution, and dynamic range. They also lack sophisticated features, such as digital memories, tracking generators, or adaptive sweep, which extend the applications of analyzers or overcome problems limiting their usefulness.

Two new models with 60 KHz and 600 KHz frequency ranges were scheduled for production by the end of 1976. They are the first Soviet spectrum analyzers to incorporate tracking generators. Their other technical characteristics continue to lag behind Western standards.

Unlike oscilloscopes, currently produced Soviet spectrum analyzers show no sign of having been copied from recent Western models. A lag in technology for high-frequency components has probably prevented the Soviets from implementing modern Western designs. However, newer models being developed in the USSR rely on Western designs, implying an improvement, actual or anticipated, in component technology.

Brochures of Soviet instruments distributed at a Moscow exhibition in mid-1975 describe a modular system of spectrum analyzers with 600 KHz, 110 MHz, and 40 GHz operating frequencies, obviously copied from a

five-year-old Hewlett-Packard design. The 40 GHz microwave analyzer has an 80 dB dynamic range and an 8 GHz display bandwidth, implying the use of YIG-tuned preselectors. However, in contrast to other items in the brochures, no model number was given for the analyzer. Thus it was probably in an early state of development and should not be taken as an index of current or imminent Soviet production capabilities. The 600 KHz and 110 MHz units have been assigned model numbers and are probably at a later stage of development, although there is no evidence that they have been scheduled for production. Their electrical parameters are similar to the US models from which they were copied, but the sensitivity, accuracy, and resolution are poorer.

Real Time Analyzers

The Soviets have long been aware of the inverse relation between high resolution and speed of processing when using conventional scanning spectrum analyzers.[12] They have been active in developing various types of real time analyzers to overcome this problem.

The Soviets have developed time compression analyzers using dispersive delay lines for use at radio frequencies. In 1966 they began production of the model S4-14 microwave analyzer (table 6). A 1974 catalog lists the much improved model S4-47/S4-50 as being in production. These analyzers were probably developed to aid in Soviet research and development of equipment with complex modulation schemes such as chirp radar. They could also be used in Elint and electronic warfare applications.

Table 6

Soviet Microwave Compressive Analyzers

	S4-14	S4-47/S4-50
Frequency range		
Basic analyzer	100 MHz	160 MHz
Including mixer	300 MHz-7.5 GHz	10 MHz-39.6 GHz
Pulse width	0.4-3 microseconds	0.4-6 microseconds
Pulse repetition frequency	one pulse-2000 Hz	one pulse-3000 Hz
Displayed bandwidth		
Pulse signals	unknown	10 MHz
CW signals	unknown	3 MHz
Resolution (CW signals)	unknown	100 KHz
Weight (with mixer)	250 Kilograms	65 kilograms

The decrease in weight by almost 75 percent for the newer model reflects the Soviet improvement in solid-state technology over the last decade. However, the resolution of this model is much poorer than that of current US designs.

[12] For example, a scanning spectum analyzer with 0.1 Hz resolution requires more than one hour and 20 minutes to analyze an acoustic signal with 50 Hz bandwidth.

At lower frequencies, the USSR has developed a number of real time compressive spectrum analyzers using recirculating delay lines. This may be the result of a high Soviet priority in areas such as high-resolution, real time analysis of acoustic signals for ship quieting and antisubmarine warfare, or vibration testing of aircraft. Such analyzers are general purpose in use, with a wide variety of applications. However, Soviet models are described in the technical literature but, with one exception, are not assigned standard nomenclatures and do not appear in instrument catalogs for sale to the general scientific-engineering community.

Soviet articles in 1966 and 1967 described the models using magnetostrictive, ultrasonic, and magnetic drum delay lines (table 7). These models were capable of resolutions of fractions of a Hz, although the operating frequency range was limited.

Table 7

Soviet and US Low-Frequency Compressive Analyzers

	Soviet					US
	Magneto-strictive	Ultra-sonic	Magnetic Drum	Ferrite Core	S4-54	
Frequency	5 Hz	400 Hz	5 Hz	1-20 Hz 5-100 Hz 25-500 Hz	0.05-2 Hz to 50 Hz-2 KHz	DC-20 Hz to DC-50 KHz
Resolution lines[1]	500	500	125	200	200	400
Resolution[1]	0.01 Hz	0.8 Hz	0.04 Hz	0.1, 0.5, 2.5 Hz	0.01-10 Hz	0.05-125 Hz
Analysis time	1 sec	0.625 sec	5 sec	6 sec	0.03 sec	0.16 sec

[1] The resolution of a compressive analyzer equals the maximum frequency divided by the number of resolution lines. Thus if a specific model has several selectable frequency ranges, the resolution will be better at the lower frequencies.

A 1972 article described a Soviet type using ferrite core memory as the delay line element. Contemporary Western low-frequency compressive analyzers use integrated circuit shift register delay lines. The use of core memory permits the Soviets to compensate for their deficiencies in integrated circuits at the expense of equipment complexity, maximum frequency, and processing time (the analyzer cannot operate in real time on its two higher frequency ranges).

The most recent Soviet low-frequency compressive analyzer, the model S4-54, was described in a data sheet distributed at an exhibition in June 1975. It is the first such analyzer to be assigned a standard nomenclature, implying that it is intended for mass production and general use. The technical characteristics imply the use of integrated circuit shift registers. However, the Soviets commonly require several years to organize actual serial production after the first appearance of data sheets describing a new instrument. Therefore, it is probable that the S4-54 is not yet in production, although small quantities of it or similar units might be available for priority

users.[13] Although successful production of the S4-54 would improve Soviet capability for low-frequency analysis, especially in terms of analysis time and wider input bandwidths, it would not represent any challenge to Western equipment. Table 7 shows specifications of a typical US low-frequency compressive analyzer for comparison.

Little is known about Soviet capabilities in Fourier transform spectrum analyzers. The Soviets have reported the use of general purpose computers for Fast Fourier Transform analysis. A 1974 book on diagnosis and reduction of shipboard machinery vibration mentions a more efficient specialized FFT processor which "is almost completely made from Soviet integrated microcircuits." No specifications for this specialized unit are given.

Digital Counters and Frequency Meters

Until the late 1960s, Soviet digital counters were limited to a 10 MHz maximum direct count rate, the same rate as the first commercial high-speed counter developed in the US in the early 1950s. By 1970 the Soviets were able to reduce their technological lag to about 10 years by taking advantage of improved components and introducing into production units rated for 50 MHz and 80 MHz. Data sheets on these instruments are ambiguous. The 80 MHz unit apparently was a basic 20 MHz counter with an internal scaler permitting operation to 80 MHz with some loss in versatility. The 50 MHz unit may have used a similar principle of operation.

As Soviet semiconductor capabilities improved in the early 1970s, digital counters were able to keep pace. Designs from the 1972-73 period, still in production, include two models rated for 50 MHz and two rated for 200 MHz. Of the latter, one appears to use 100 MHz decade counting units and the other, 50 MHz units, with the 200 MHz ratings being obtained with internal scalers. In the US, units are available with direct decade counting units operating above 500 MHz, or operating with internal scalers to beyond 1000 MHz.

In the Soviet instrument industry, it is common practice to publish data sheets describing new instruments well before serial production has begun and to demonstrate prototypes at exhibitions. This serves to create an overly favorable impression among foreign observers as to Soviet technical capabilities and to alert Soviet engineering and technical personnel as to what may become available in the future. For the last several years, however, no data sheets or prototypes of new Soviet high-speed digital counters have been observed. At a 1975 Soviet exhibition of instruments, many prototypes of oscilloscopes, spectrum analyzers, and other types of instruments were shown. However, the digital counters at the exhibition were the older 50 and 200 MHz units described above.

---

[13] At a more recent exhibition, a Soviet national commented that difficulties were being experienced with the development of an unidentified time compression processor because of a lack of components.

The lack of new digital counters is probably an indication of problems with developing high speed semiconductors. The maximum frequency of a digital counter is largely determined by the speed of the digital scaler (if any) and decade counting circuits. It is likely that the Soviets either have been unable to mass-produce sufficiently fast semiconductors or are not able to produce a sufficient number to meet the demands of the instrument industry as well as higher priority consumers.

APPENDIX B

Data on production of electrical measuring instruments for all years and of radio measuring instruments through 1969 were taken from the yearly statistical handbook *Narodnoye Khozyaistvo SSSR*. Through 1969 the handbooks indicated the total ruble volume of output of instruments of all types, together with a breakdown into 10 subsectors, two of which were electrical and radio measuring instruments. In 1970 the USSR stopped publishing data on the output of radio measuring instruments, giving only the total output and nine subsectors. However, the missing figure can easily be derived by subtracting the output of the nine subsectors from the total. Data on production of radio measuring instruments for 1970 and later years were derived in this way.

The author of this paper is [redacted] *Soviet Machinery Branch, Office of Economic Research. Comments and queries are welcome and should be directed to* [redacted] *351-6716.* 25X1A

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